

SatCAT



Impact of Space Weather on the Satellite Industry

Janet Green- Space Hazards Applications, LLC
Justin Likar
Yuri Shprits

Outline

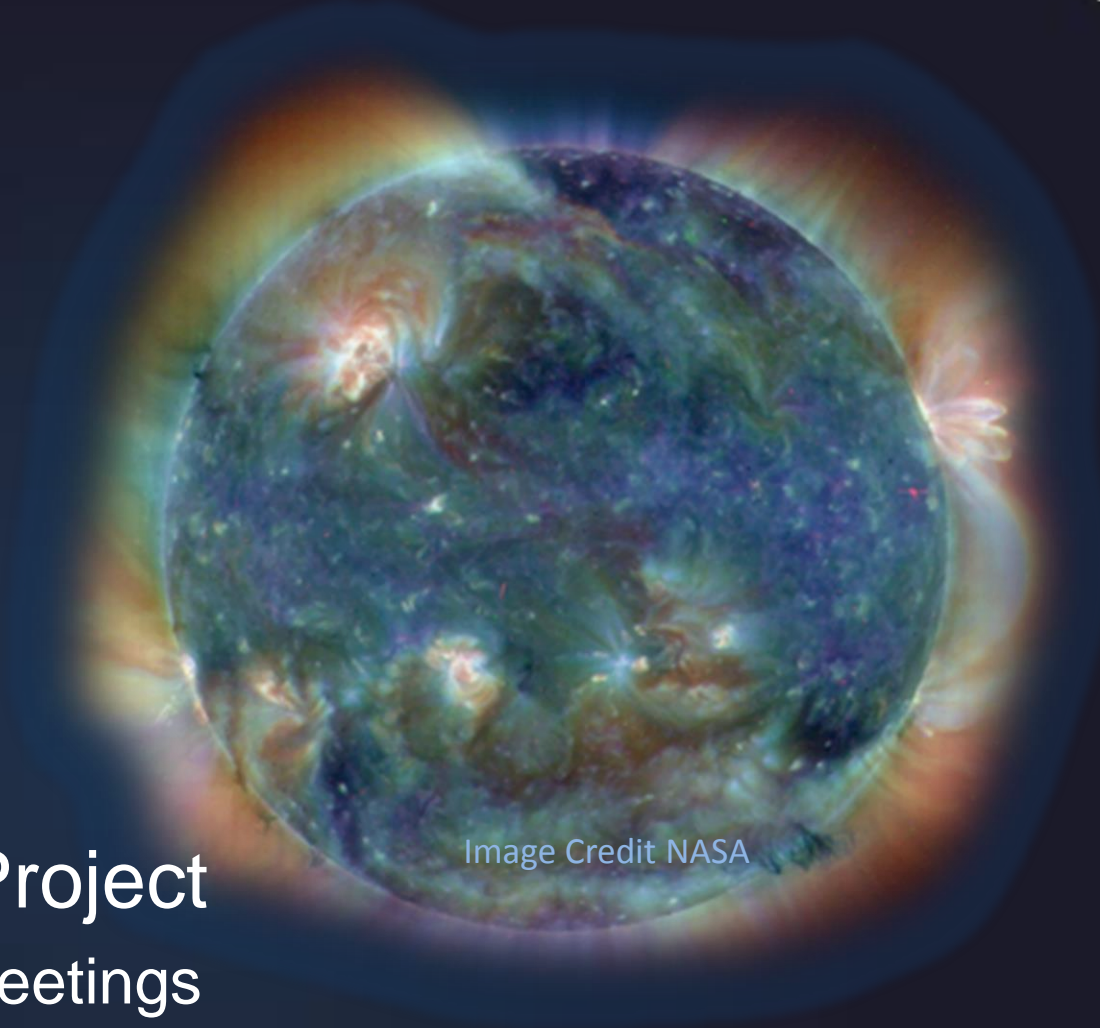
Background

- The Issue
- The Challenge
- The Concern

The SatCAT SBIR Project

- Satellite Industry Meetings
- Prototype SatCAT tool

Summary



The Issue

Space weather causes satellite anomalies and disrupts operations

Surface Charging:

Charged particles collect on satellite surfaces producing high voltages, damaging arcs (electrostatic discharges), and electromagnetic interference.

Internal Charging:

Energetic electrons accumulate in interior dielectrics (circuit boards or cable insulators) and on ungrounded metal (spot shields or connector contacts) leading to electrical breakdown in the vicinity of sensitive electronics.

Single Event Upsets:

Energetic ion passage through microelectronic device node causes instantaneous catastrophic device failure, latent damage, or uncommanded mode / state changes requiring ground intervention.

Total Ionizing Dose:

Energy loss (deposited dose) from proton or electron passage through microelectronic device active region accumulates over mission (or step-wise during high dose rate events) causing device degradation and reduced performance at circuit or system level.

Image Credit NASA/SDO



The Challenge

Effects are caused by distinct particle populations that intensify under varying conditions and in different regions

Surface Charging:

Low to medium energy particles associated with substorms during moderate Kp activity in the dusk magnetospheric regions.

Internal Charging:

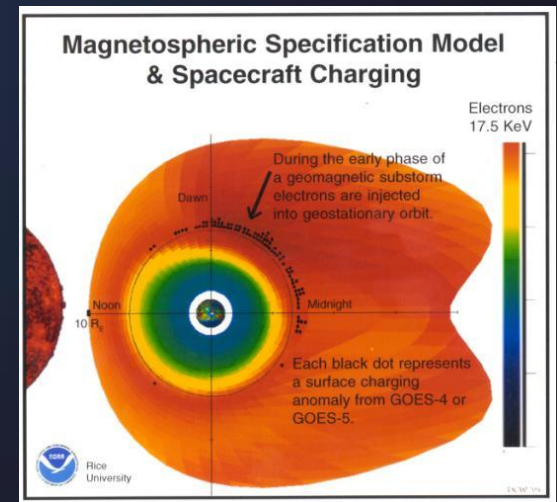
Higher energy electrons associated with some storms that peaks around L=4

Single Event Upsets:

Solar Proton Events associated with solar flares and coronal mass ejections

Total Ionizing Dose:

All of the above.



The Concern

Growing Industry and Increasing Reliance

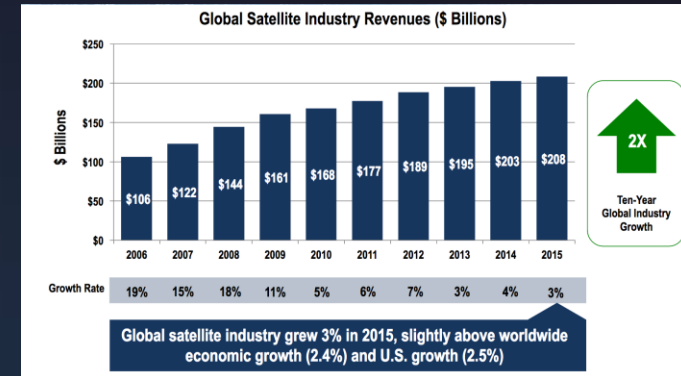
3% growth & 208 B revenue (SIA 2016)

New services with large constellations

- Satellite internet
 - O3B/SES- 12 sats 8000 km (20 planned)
 - Onweb- planned 720 1200 km (2017 launch)
 - SpaceX- proposed 4000 satellite constellation
- Satellite Imaging
 - Earth observation services revenues grew 10%
 - Digital Globe, Terra Bella, Planet Labs
 - Uses: port traffic, mining development, agriculture, forestry

New Technology

- Electric orbit raising



Credit: Airbus Defense and Space

SatCAT Project

SatCAT project- funded through the NOAA Small Business Innovative Research Program.

SBIR- a way to provide innovative solutions to problems not easily addressed within the government framework.

Phase I: Two objectives

- Deliver a report on satellite industry needs related to space weather
- Build a prototype satellite charging assessment tool

Phase II:

- Continue satellite charging assessment tool development
- Approved contingent on funding

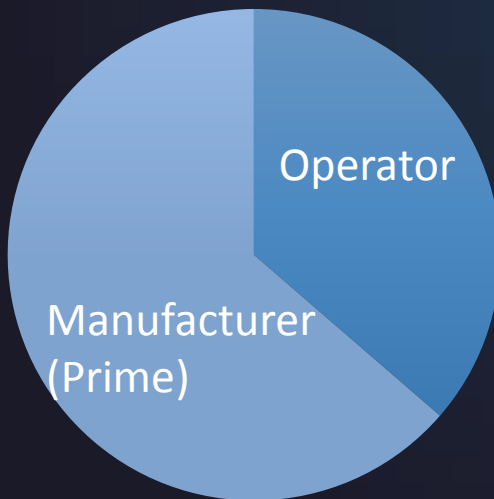


Industry Meetings

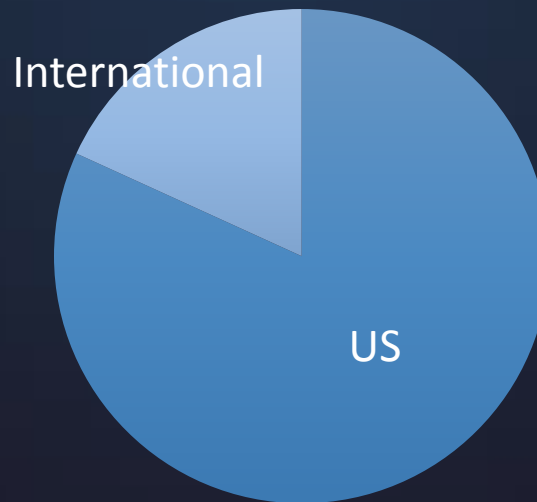
Candid and “as specific as possible” inputs drive end-product utility & effectiveness

- Focused conversations to avoid conference / workshop style setting
- 10 such meetings ensure effective range of inputs, experiences, & needs
- Included survivability engineers, customer/on-orbit response teams
- Greater interest from manufacturers

Mix of Stakeholders



Global reach



Cover LEO to GEO



Findings

Some Findings

- Space Weather Impacts and Severity
- Managing Space Weather Issues

Details and suggested solutions in paper submitted to
Space Weather Journal

Findings

Space Weather Impacts and Severity

Satellite fleet is robust to space weather impacts but not entirely impervious

- Most impacts are not considered severe or mission limiting and require simple power cycle to correct
- Some are more problematic (not yet in the public domain)

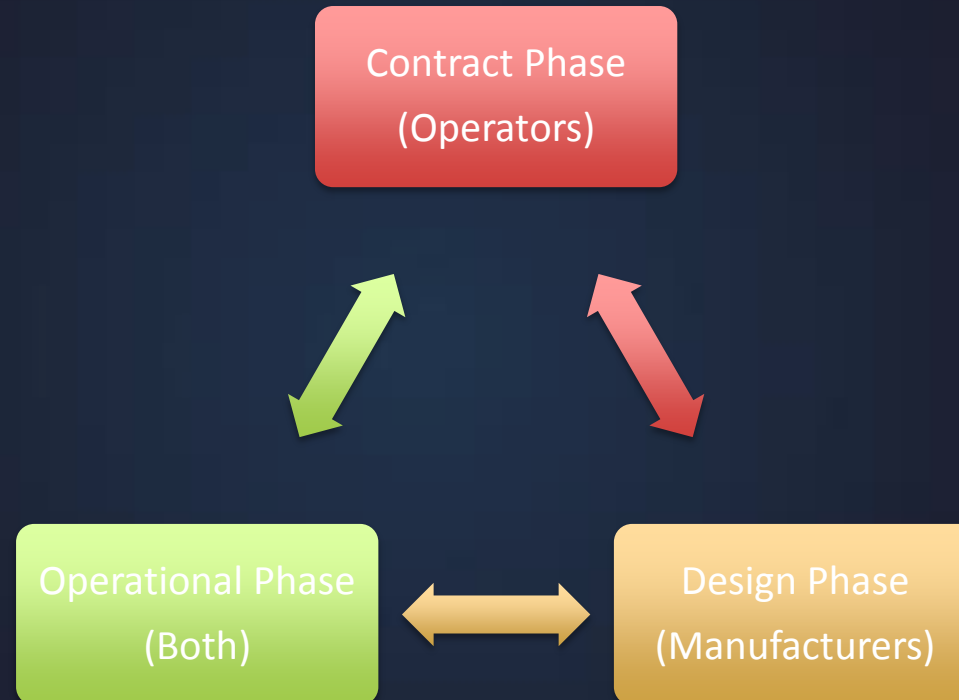
Concern that recent mild conditions promote a false sense of security

SEE were greatest concern/issue

- SEE's are sometimes a catch-all for infrequent unexplained events

Findings

Management of space weather issues is a shared responsibility between manufacturers and operators



The extent and detail of space weather management and response varies greatly depending on the role, the impact, in house expertise, and budget.

Findings

Management of space weather issues is a shared responsibility between manufacturers and operators

Both Operational
Phase

Operators

- Monitor telemetry and look for issues
- Confer with manufacturers when anomalies occur
- Investigate response but not cause

Manufacturers

- Customer response team guides actions
- May do simple investigations but cost is not covered in contract
- Larger investigation (ARB) only if impact affects future satellites

Some anomalies go undiagnosed due to

- Lack of specific quick attribution tools and training
- Lack of information sharing between ops and manufacturers
- Lack of anomaly sharing within the industry

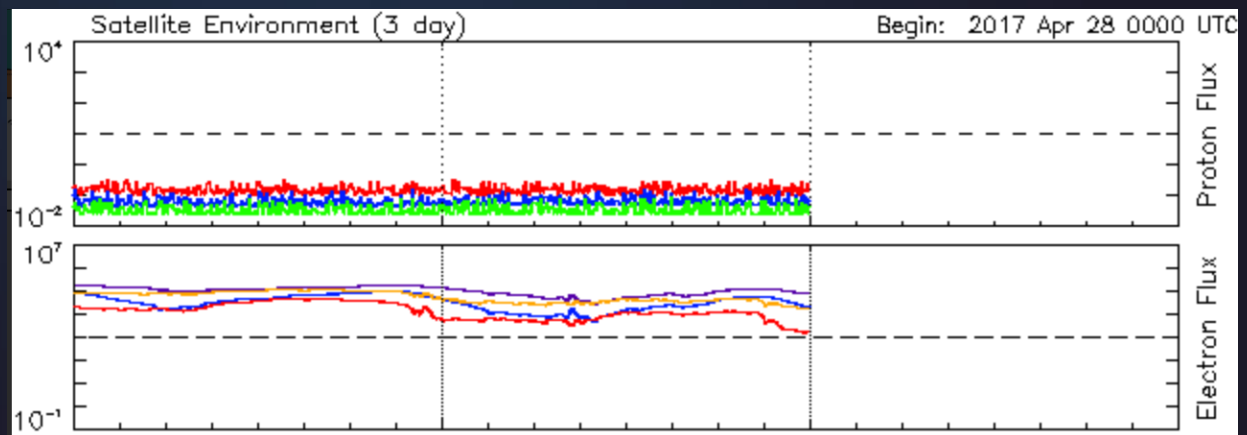
Attribution Challenge

Anomaly Investigation/Monitoring

Current Method:

Most referred to NOAA GOES particle environment plots

- Difficult to compare to full mission
- Fluxes still need to be translated into one of the four specific hazards
- Fluxes at GEO do not describe full magnetosphere

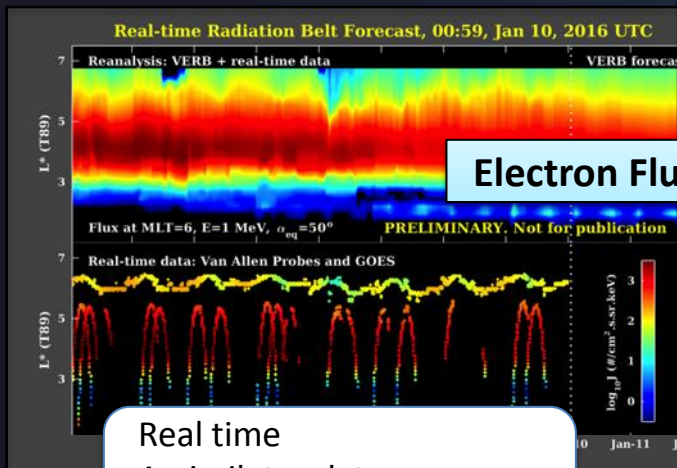


About SatCAT

Allows you to respond quickly and confidently with the right action

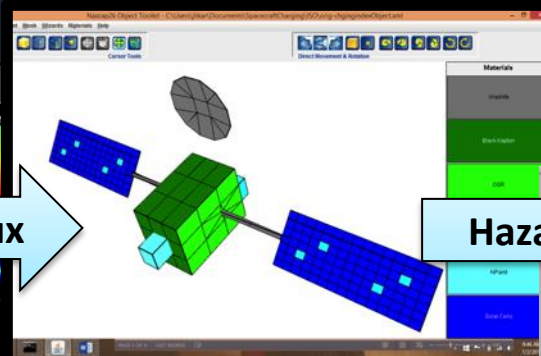
ENGINEERING HAZARD MODULES

RADIATION DATA/MODEL



Electron Flux

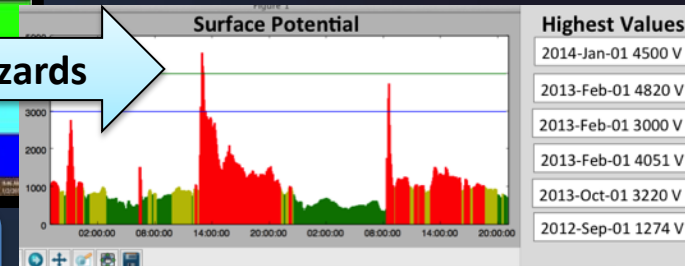
Real time
Assimilates data
All orbits nowcast/forecast



Hazards

Satellite specific
Real charging hazards
Voltage, Accumulated charge

DISPLAYS OUTPUTS



Multi-day history
Stoplight coding
Dates of past highest levels
Comparisons to specs/other events

Combination physics &
engineering based
approach

End product developed with
focus on the customer

How it works

Environment -< Engineering Hazard -< Displays

The Environment

At your satellite along your orbit

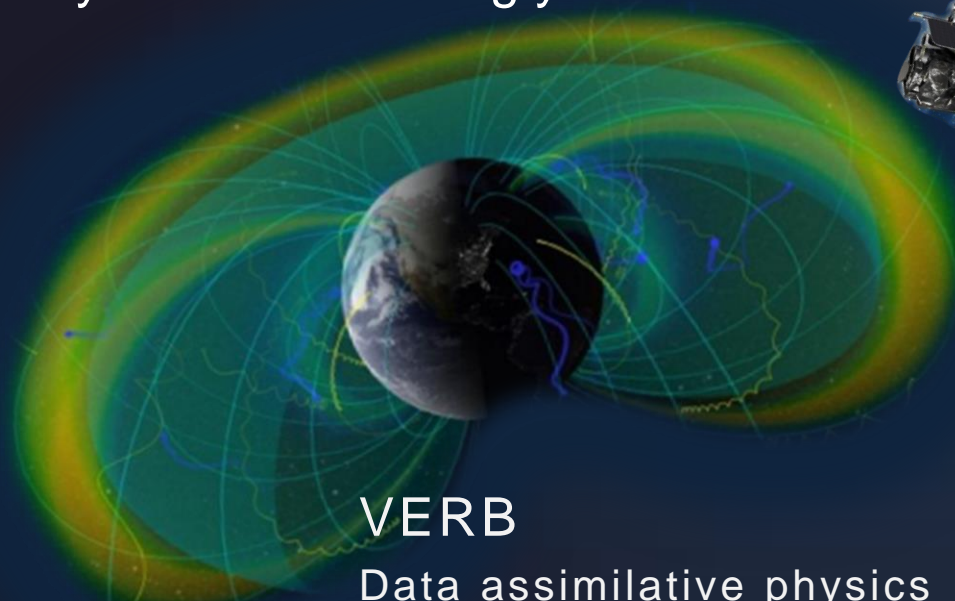


Image Credit NASA

VERB

Data assimilative physics based model specifies the environment globally

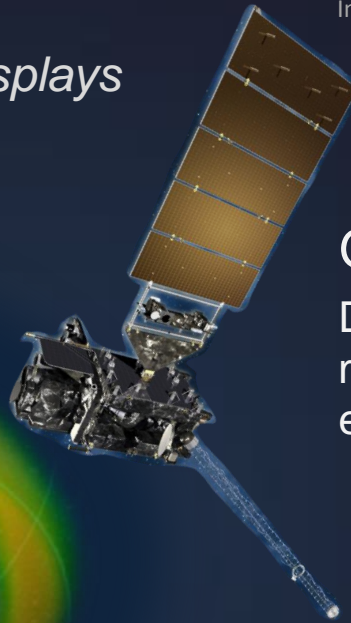
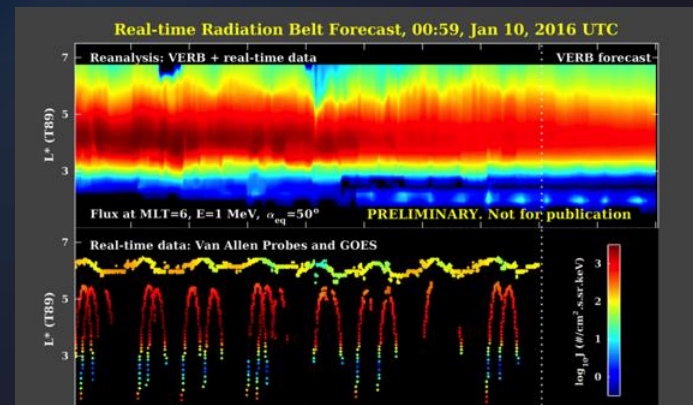


Image Credit NOAA/NASA

GOES

Direct particle flux measurements specify the environment locally at GEO

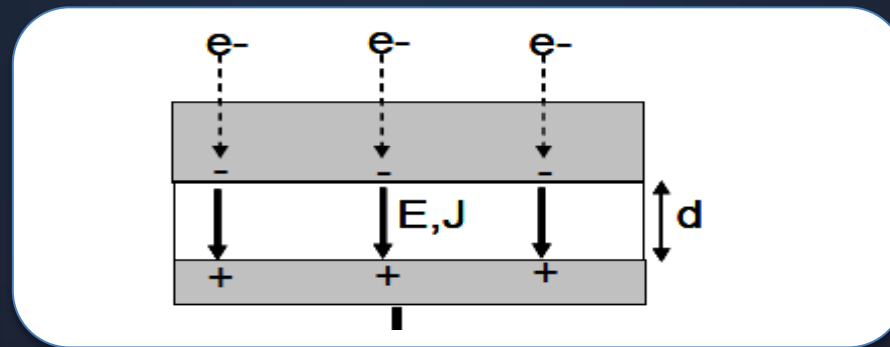


How it works

Environment -< Engineering Hazard-< Displays

The Hazard

At your satellite along your orbit
for your architecture



Internal Charging

Total charge accumulation calculated for
chosen layers of shielding and dielectric
materials

How it works

Environment -< Engineering Hazard-< Displays

Displays

The hazard at the satellite
along its orbit
for its architecture,
thresholds
and events



New Development

Anomaly Investigation

Phase II:

- Secure user login
- Generate new data for specified orbits, shielding and materials
- View displays
- Access data

The screenshot displays the SpaceHaz web application interface. The browser window title is "SpaceHaz - Home" and the address bar shows "spacehaz.com". The interface includes a search bar and a menu icon. The main content area contains several buttons and input fields:

- Buttons: "View Displays", "Access Data Files", "Generate Data", and two "GO" buttons.
- Input fields:
 - "NORAD Satellite ID :"
 - "Internal Charging" section:
 - "Shielding Thicknesses (mils Al) :"
 - "Materials:" with a dropdown menu labeled "Pick an Item"
 - "Start time:"
 - "Stop time:" with a dropdown menu labeled "present"
 - "Surface Charging" section:
 - "Satellite Model:" with a dropdown menu labeled "Pick an item"
 - "Start time:"
 - "Stop time:" with a dropdown menu labeled "present"

Summary

Large changes in satellite industry increase concerns regarding space weather

Report on Satellite Industry Needs

- Submitted to Space Weather Journal

SatCAT

- For operators/designers who need to maintain mission operations and resolve unavoidable satellite anomalies, SatCAT is a tool that summarizes space weather impacts to specific asset to quickly make confident decisions.
- Prototype running now
- Phase II development tentatively approved for two years to turn SatCAT into a commercial product